PROCESS FOR MANUFACTURING DRAWN METAL PARTS

Cross Reference to Related Applications

[0001] This application claims priority of provisional application Serial No. 60/437,531 filed December 31, 2002.

Background of the Invention

[0002] This invention relates to a high volume manufacturing process for continuously manufacturing drawn metal parts that require a series of sequential intermediate operations to produce finished drawn metal parts. An example of high volume manufacturing of drawn metal parts is the production of battery cans, which are used as the primary battery casing for commercial cells, such as A, AA, AAA, C. D. F. M, etc.

[0003] Manufacturing of battery cans according to the prior art is generally accomplished by a batch and queue process in the following manner. A redraw press accepts narrow strip stock from a payoff reel and performs blanking, cupping and subsequent redraw operations. The entire battery can is manufactured in each stand-alone redraw press and the cans are collected in bulk in containers. The press operator and/or toolmaker manually inspect the dimensional and cosmetic attributes of the can. A pre-determined number of cans are removed randomly and inspected. Next the containers of parts from the press are moved to a staging area near a washer/dryer machine. The washer/dryer, which removes the drawing lubricant, is typically a rotary bulk washer with a cob dryer. An operator feeds the cans into the inlet of the washer. The washed cans are caught in bulk hoppers or cartons.

[0004] Next the washed cans are moved to a staging area near a coating machine. The coating machines apply thin film of coating material to the interior of the can. The cans are dried in bulk in a curing oven. An operator feeds the cans to the coaters. The cans are inspected for proper coating and then placed into the final packaging containers.

[0005] The batch and queue process described above has several disadvantages. The narrow strip stock produces significant scrap, due to unusable material at the edge of the strip. The required coil changes to feed the narrow strip stock to the redraw press lead to inefficiencies in operation. Damage can occur due to parts contacting other parts in the batch

containers. Rejection of parts due to dimensional, coating and cosmetic defects may be inconsistent due to using different inspectors.

[0006] When batch operations are converted to sequential processing in a production line, the throughputs of intermediate production machines or intermediate processes may not be in balance. This causes part shortages or excessive accumulation of parts at different stages in the process. It is desirable to accommodate temporary under-production or over-production of intermediate production machines.

[0007] Accordingly, one object of the present invention is to provide a continuous high volume process for manufacturing drawn metal parts.

[0008] Another object of the invention is to control the speed of intermediate manufacturing steps so as to optimize the overall flow of parts.

[0009] Another object of the invention is to maintain identification of the source of parts through the manufacturing process, while accommodating temporary over-production or under-production in intermediate production machines.

Summary of the Invention

[0010] Briefly stated, the invention comprises a process for controlling the speed of intermediate production machines arranged to continuously perform sequential operations on drawn metal parts, comprising the steps of providing a group of drawing press tools independently producing segregated streams of drawn metal parts, merging the segregated streams into a single ordered stream of drawn metal parts, providing a first intermediate production machine receiving the ordered stream and performing a first operation on the drawn metal parts, measuring the rate of production of drawn metal parts in each of the segregated streams, selecting the highest rate of production of a segregated stream, and then controlling the rate of production in the first intermediate production machine as a function of the selected highest rate of production. In the preferred form of the invention, a buffer is supplied with drawn metal parts by the first intermediate production machine. The buffer holds a pre-selected normal level of drawn metal parts, and discharges parts at a variable discharge speed responsive to the level of drawn metal parts above or below the pre-selected normal level. A second intermediate production machine receives parts from said buffer and performs a second operation on the drawn metal parts. The second intermediate production machine receives parts in response to the variable discharge speed of the buffer.

Drawing

[0011] The invention will be better understood by reference to the following description, taken in connection with the accompanying drawing, in which:

[0012] **Fig. 1** is a simplified block diagram of the manufacturing process,

[0013] **Fig. 2** is a schematic representation of a merge and sequence machine,

[0014] **Fig. 3** is a schematic representation of portions of a conveyor, with means to remove a part for inspection,

[0015] **Fig. 4** is a schematic representation of apparatus used to coat drawn metal parts,

[0016] **Fig. 5** is a schematic diagram of the packing process, and

[0017] **Fig. 6** is a perspective view showing the actual placement of equipment, with simplified diagram of the process computer controls.

General Description of the Process

[0018] Referring to **Fig. 1** of the drawing, a coil payoff system **10** feeds a cupping press **12** with a wide strip of thin metal from a coil. Cupping press **12** performs a blanking and drawing operation to produce seven cups at a stroke, which are fed onto a magnetic conveyor **14**. The flow of parts from the cupping press **12** divide into two "cells" **A** and **B**. Either cell **A** or **B** may operate independently of the other throughout much of the manufacturing process, even though they rejoin to share some equipment toward the end of the process.

[0019] Conveyor **14** supplies the cups to redraw presses **16, 18** in cell **A** and to redraw presses **20, 22** in cell **B**. In order to provide for possible downtime of cupping press **12** and/or redraw presses, part accumulators **24, 26** act as buffers to receive or discharge cups as necessary. Accumulators **24, 26** are towers with helical tracks for temporary storage of parts with control means to switch parts to the presses if the cupping press is not operating, but any type of storage capable of accumulating and discharging parts via conveyors will be suitable.

[0020] The redraw presses **16, 18, 20, 22** each are equipped with at least two sets of redraw stations, hereinafter defined "tools". As defined in this patent application, a "tool" (singular) is actually a set comprising several redraw punches and dies, which successively draw the cups into the final dimensional shape of a battery can and cut off the top rim of the can. Thus, in the illustration shown, each press handles two "tools" and, therefore, produces two parts during each stroke. However, more than two tools per press are also possible.

[0021] Battery cans from each of the tools in each of the redraw presses are discharged onto a separate conveyor, such as that indicated by reference number **28**. Means are provided to remove a sample for local inspection as shown at **30**. While a single conveyor **28** and its inspection station **30** are indicated on the drawing for tool number four of redraw press **18**, a similar arrangement is placed at the tool discharge of each redraw press. If there are more than two tools in each redraw press, additional conveyors will be required, one for each tool.

[0022] Battery cans **1, 2, 3, 4** from presses **16, 18** in cell **A** are separately accumulated in four serpentine tracks, one for each tool, in an accumulator **32**. Similarly battery cans **5, 6, 7, 8** from redraw presses **20, 22** in cell **B** are separately accumulated in four serpentine tracks in accumulator **34**.

[0023] A special ordered merge device **36** in cell **A** and an identical device **38** in cell **B** perform an ordered merge operation to be described later in detail. Briefly the separate streams of parts from the tools of each of the presses are merged into a single ordered stream of parts maintaining a sequential order that enables identification of the tool by the location of the part in the stream. This ordered stream of parts is represented by the dashed lines **40 - 42** representing the conveyors from the ordered merge **36, 38**.

[0024] An automatic dimensional inspection machine **44** is shared by both cells **A** and **B** and equipped with instruments, which measure certain critical dimensions in the battery cans. Part ejectors **46, 48** are precisely controlled to remove a part from a pocket on a conveyor **40, 42** and place it in the dimensional inspection equipment **44**. It is important to note that the empty pocket in the conveyor from which the part is removed is maintained throughout the manufacturing process, so that the integrity of the ordered stream is maintained as the battery cans move through the process. This integrity is maintained when parts are transferred from one conveyor to the next.

[0025] Battery cans from cell **A** and cell **B** are conveyed to washer/dryers **50, 52** respectively. There, the drawing compound is removed and the battery cans dried. Thereafter, each washer/dryer **50, 52** supplies a buffer **54, 56** respectively. Buffers **54, 56** are maintained half-full by a moveable bridge mechanism. The buffer level controls the speed of the coating/inspection conveyor downstream of it.

[0026] Optical camera inspection systems **58, 60** measure the streams of battery cans from the buffers **54, 56**. The parts are fed in order maintaining gaps for any missing parts, onto special motion converting conveyors **62, 64** equipped with coating guns. These devices

will be described further in detail, but, briefly stated, the continuously moving stream of parts is converted to an intermittently moving or indexed motion having a dwell time and a move time. During the dwell time, the cylindrical battery cans are rotated while they are sprayed on the inside with coating guns. Following the coating operation, an automatic optical inspection system at **66**, **68** inspects internal coating, and any cosmetic anomalies on the exterior of the battery can. Rejects are automatically removed by part ejectors **70**, **72**. The parts, still segregated in the respective conveyor pockets for the two cells **A**, **B** move to a coating dryer **74** and, from there, to the pack operation indicated at **76**.

Ordered Merge Operation

[0027] While the preceding section describes the overall process for manufacturing drawn metal parts in a general discussion, several aspects of the process will be described in detail. One of these is the ordered merge operation, which combines the separate streams of parts from the separate drawing press tools in such a way that the sequence is always the same and is repeated periodically. In this way, the segregated stream of parts are merged into a single ordered stream of drawn metal parts having a sequential order which enables identification of the drawing press tool in which the part was made.

[0028] **Fig. 2** illustrates in simplified diagrammatic fashion the ordered merge operation. It will be understood that the actual configuration will vary according to size and type of the parts, as well as variations in the components. The ordered merge machine is shown generally at **80** and comprises four separate accumulating receptacles **82**, **84**, **86**, **88**. These are part of the accumulators **32** or **34** shown in **Fig. 1**. Each such accumulating receptacle receives drawn metal parts from a different tool, in this case parts **1**, **2**, **3** and **4** coming from tool one, tool two, tool three, and tool four respectively of presses **16**, **18** (**Fig. 1**). Whenever parts **1**, **2**, **3** and **4** are depicted in the following drawings, they are deemed to be from their corresponding source tool, although they may appear at different places in the processes to be described. Accumulating receptacles **82**, **84**, **86**, **88** supply feed wheels **90**, **92**, **94**, **96** respectively. The feed wheels supply parts to a merge wheel **98** which feeds a conveyor **100**. The feed wheels have pockets, such as **102**, and the merge wheel **98** has pockets, such as **104**. The feed wheels are mechanically geared to the merge wheel, so that a pocket **102** on an feed wheel registers with every fourth pocket **104** on the merge wheel as the wheels turn.

[0029] If there are more than two tools on each redraw press, e.g., three tools, the feed

wheels and index wheels must be modified accordingly to include the proper number of pockets.

[0030] Conveyor **100** is designed to have a carrier belt **106**, with dividing walls **108** providing segregated pockets **110**. The speed of the conveyor **100** is timed to coincide with the speed of the merge wheel **98**, so that the pockets **104** on the merge wheel feed the segregated pockets **110** on the conveyor in precise order. **Fig. 2** illustrates that accumulating receptacle **86** was temporarily empty, so that feed wheel **94** was previously not feeding parts **3** to the designated pocket on merge wheel **98**. Therefore the segregated pockets **110** on conveyor **100** are temporarily empty, but the single ordered stream of parts continues to flow to the next intermediate processing operation.

Part Ejectors

[0031] The process provides for removal of parts at various points of the process for dimensional inspection, for local tool maker inspection, for defects located at any point in the process. Such part ejectors are shown on Fig. 1, for example, at 29, 46, 48, 70, 72. Fig. 3 illustrates schematically, in simplified form, the operation of such a part ejector. A conveyor 112 is made up of articulated links 114 hinged together at pivot points (not shown). Each such link has a divider wall 116 projecting upwardly from the link platform. The space between divider walls 116 provides segregated pockets for the parts 1, 2, 3, 4 supported on the platforms of the articulated links 114. The drawn metal parts are cylindrical and each has an open end 118, as is typical of battery cans and similar drawn parts.

[0032] Removal of parts is accomplished with an air jet 120 having a tip 122 aligned with the open end of the parts, and a collection tube 124 having an open end 126 aligned with the axis of the air jet. The collection tube is provided with directed openings 128 which are, in turn, surrounded by a manifold 130. When it is desired to remove a part, air jet 120 and manifold 130 are supplied with a blast of high pressure air, pushing the part 3 into the open end 126 of the collection tube 124. Air entering the manifold 130 and openings 128 propels the part 3 through the tube to a collection point (not shown).

[0033] This arrangement is known as a "bazooka", and may be either automatically or manually actuated to remove a part from a segregated pocket. Since the parts are in sequence, the part corresponding to any selected tool source may be removed. The location of the pocket on the conveyor is a function of the conveyor speed which is precisely known

by an encoder, and controlled by a programmed logic computer (see **Fig. 6**).

Coating Operation

[0034] Referring to **Fig. 4** of the drawing, a conveyor **132** is provided with a known type of mechanism (not shown) to convert a continuous movement to an indexed movement having a move time and a dwell time. The coating operation involves spraying a conductive coating into the open ends of the drawn metal parts. Coating is accomplished by means of coating spray guns **A**, **B**, **C**, **D**. These are spaced along conveyor **132**, which is moving from left to right in the drawing, so that each spray gun is automatically actuated to spray a jet of coating material into the open end of the part during the dwell time of conveyor **132**. Rotating apparatus (not shown) is also provided to rotate the cylindrical parts about their axis while the spray gun is active so as to obtain a uniform coat. Spray guns **A**, **B**, **C**, **D** are spaced along conveyor **132**, so that coating gun **A** coats part **1**, coating gun **B** coats part **3**, coating gun **C** coats part **4**, and coating gun **D** coats part **2**.

[0035] Because of the possibility that one or more coating guns may become inoperative, a unique system is employed to enable a coating gun to take over the job of an inoperative coating gun, while continuing to process its previously assigned part. The coating guns are capable of firing twice as fast as their normal firing rate. Also, coating guns **B** and **C** are able to shift one position along conveyor **132** to the alternate respective positions indicated by reference letters **B'**, **C'**.

[0036] Method 1: If gun **B** should become inoperative, it will be observed that coating gun **A** may be operated at twice its regular firing rate to coat parts **1** and **3**. Similarly, gun **B** may take over for gun **A** should gun **A** become inoperative. In a similar manner, guns **C** and **D** may assume the duties for each other by firing at twice the normal rate.

[0037] Method 2: Should both guns **C** and **D** become temporarily inoperative, gun **B** may be shifted to position **B'**. With both guns **A** and **B'** firing at twice the normal rate, they can take over the job of coating all four parts. In a similar manner if both guns **A** and **B** become temporarily inoperative, gun **C** may be shifted to **C'** and guns **C'** and **D**, firing at twice the normal rate will coat all four parts.

[0038] The coated parts are inspected by an optical inspection system **134** and removed by a parts ejector **136** if they should be unacceptable.

Packing Segregated by Tool

[0039] Referring to **Fig. 5** of the drawing, a packing area shown generally as **138** receives an ordered stream of parts **1**, **2**, **3**, **4** on a conveyor **140** from cell **A** and a second ordered stream of parts **5**, **6**, **7**, **8** on a conveyor **142** from cell **B**. In keeping with the philosophy of the inventive process, some of the pockets of the conveyors may be empty because of removal of parts upstream for various purposes. A series of receptacles **144** are provided, each one from a different tool. A U-shaped conveyor **146** carries boxes of parts from a box filling area shown generally as **148** to a box collection area shown generally as **150**.

[0040] Empty boxes are supplied along a first table (or conveyor) **152**. Boxes being filled are stationed along a second table (or conveyor) **154** and, when full, are pushed onto conveyor **146**. The filled boxes are then conveyed to a specific collection station, such as the one designated at **156**. From there they are removed for shipment, the boxes being coded to designate the source tool from which they were manufactured.

Dimensional Test Unit

[0041] Referring to **Fig. 1** of the drawing, dimensional inspection is carried out by dimensional test unit **44**. This unit is designed to measure, via touch probes, pre-defined dimensions on the parts. The unit will measure parts from eight tools plus allowance for manual insertion/inspection of parts. The unit provides for measuring, indexing and discharge of parts. A detailed description of the device as used to measure that parts is beyond the scope of this application. However, such devices are known in the prior art. Part ejectors such as previously mentioned in connection with **Fig. 3** are attached to conveyors feeding the washer/dryers **50**, **52**, as indicated at **46**, **48** in **Fig. 1**. The parts are introduced vertically, closed end down. An electromagnetic brake holds the part momentarily, and then releases the part into the pocket in the dimensional test unit **44**. When the dimensional test unit is in automatic mode, parts are requested for dimensional measurement in a pre-selected sequence. A signal is received from an encoder on the conveyor informing it that the requested part is positioned in front of the part ejector. The part ejector is activated and the part enters the dimensional test unit.

[0042] The dimensional test unit measures a part approximately every 10 seconds. If eight tools are running, there will be an 80 second delay between the time a part is measured and the time a part from the same tool is measured again. If a defective part is detected, a

second part from the same tool should be requested as soon as possible to verify the original result. Since the line is continuing to move, there could be a considerable number of defective parts downstream, as well as those upstream from the defective tool. The dimensional test unit sends the appropriate signals to stop the press with the defective tool, to stop the discharge conveyor from the appropriate buffer **54**, **56**, and to activate appropriate parts ejectors to purge the line of all parts from that tool, both upstream and downstream. Corrective action on the defective tool may then be taken, while the line continues to run, maintaining empty pockets corresponding to those pre-selected for that particular tool.

Process Speed Control

[0043] The manufacturing system includes various safeguards and control devices to maintain production of drawn metal parts in an optimum manner, and maximize overall production, while assuring that failure or defective operation of any piece of equipment does not shut down the entire line. Reference to **Fig. 6** shows a perspective view of the actual configuration of the production line. Only cell **A** is indicated on the drawing, along with apparatus that is shared by cells **A** and **B**. The reference numbers of the pieces of equipment correspond to those in **Fig. 1**. A programmed logic computer **158** is representative of one or more programmed logic computers receiving signals and sending commands represented by phantom lines. Any deficiency in cups from the cupping press that is detected at **160** is communicated over lines **162** to controls for the spiral tower buffer **24** to augment the supply. Shortage of parts in the buffer **24** signals cupping press **12** over line **164**.

[0044] Press strokes per minute of the four redraw presses are detected and communicated to PLC **158** over lines **166, 168**. Press stroke speeds are used in a computer program to set the speed of ordered merge unit **36** and washer/dryer **50** over control line **170** as a multiple of the fastest press stroke speed. The speed of the discharge from buffer **54**, which is supplied by the washer/dryer is set to vary in accordance with a selected normal level of the buffer, speeding up as the buffer level of parts rises and slowing down as it lowers. This is indicated by control line **172**. The merge wheel for ordered merge unit **36** is directly driven by the washer **50**. Any back-up of parts into the separately fed accumulators **32** is detected by sensors located at **174** and shuts down the appropriate press. The coating lines and their associated conveyors **62** are controlled by the speed of the discharge conveyor from buffer **54**, as indicated by control line **176**. While a coating operation is shown in the

present description as being controlled by the buffer discharge speed, any intermediate production machine could be controlled in the same manner, so as to adjust for temporary over-production or under-production of an upstream intermediate production machine.

[0045] Therefore, it can be seen that by provision of appropriate accumulators and buffers at various stages in the process, as well as controlling the conveyor speed of intermediate upstream or downstream processing units, the continuous in-line process can continue to operate at optimum speed. This is despite the removal of parts at various points in the process for inspection or due to faulty manufacture.

[0046] Other modifications of the invention will become apparent to those skilled in the art and it is desired to cover all such modifications as fall within the true spirit and scope of the invention.